I – Problem Statement Title (04-GS083)

Determining Methods to Control the Effects of Heat of Hydration and Other Concerns Associated with the Placement of Mass Concrete for Cast-in-Place Concrete Piling

II – Research Problem Statement

Question: Are the general concerns attributed to the placement of concrete for other massive bridge components, with regards to controlling the heat of hydration, also applicable to concrete placement for large diameter cast-in-place piling, and what measures are effective in controlling these effects without negatively affecting constructability?

III – Objective

Evaluate the negative effects of the cracking resulting from uncontrolled mass concrete placement and weigh these effects against the negative effects of restricting the flow of concrete in the piling with cooling tubes or other temperature controlling devices. Also, are the concerns for concrete cracking for a large diameter piling (which is usually under sustained compression for non-seismic load cases) the same as for thick footing and bent caps. The results of this research would result in consistent use of the mass concrete specification by design engineers.

IV – Background

The current standard special provisions for mass concrete placement of structural elements that have a least dimension in excess of two meters has been revised to exclude cast-in-place concrete piling.

Temperature sensors have been placed in large diameter Cast-in-Place piles and readings have shown that the differential temperature from the center of the pile to the outside edge of the pile can exceed the tolerance specified in the standard special provision. Also, the maximum temperature reached in the pile can exceed the specified maximum allowable temperature. The reason for excluding piles from the requirements of the mass concrete placement was because the Caltrans Structure Design Substructure Committee and the Association of Drilled Shaft Contractors (ADSC) agreed that the potential increase in QA related to controlling the heat of hydration of the shaft concrete was offset by the decrease in QA of placing obstructions to the flow of concrete in the shaft (cooling tubes) or adjusting an already fine tuned concrete mix design.

V – Statement of Urgency and Benefits

A. Support of the Departments Mission and Goals:
(Improving Mobility: Safety, Reliability and Performance)

In partnership with the bridge contractors, we realize that excessive cracking will develop in massive concrete bridge elements where the heat of hydration is not controlled during the placement of concrete. In flexural elements such as footings or bent caps, these cracks will open up as the extreme fibers go into tension. This results in a loss of capacity and

exposure to corrosive conditions. Therefore; the contract requires that the concrete for these components be placed in such a manner that the rate of increase in the heat of hydration is controlled, usually by incorporating cooling pipes into the bridge elements.

Cast-in-place concrete piles can also be massive bridge elements; however, they are usually under a sustained compression (cracks remain closed) until an extreme event causes a large lateral loading. Casting concrete into a drilled hole is more difficult than casting concrete into forms, obstructions in the hole, such as cooling tubes, could adversely affect the flow of concrete, which would affect the piles capacity.

Performance of the pile will affect the safety of the structure. Requiring the cooling tubes could affect the flow of concrete, which could adversely affect the performance of the pile. However, the cracking resulting from not controlling the heat of hydration could also adversely affect the performance of the pile.

B. Return on Investment

Requiring that the concrete for cast-in-place piles be placed in a manner that will control the heat of hydration of the concrete will require the contractor to take measures that increase cost of cast-in-place pile construction, also placing obstructions in the hole will increase the risk that anomalies will be formed within the pile. By not controlling the rate of heat of hydration in cast-in-place piles, we will develop cracking in the piles. If these cracks are determined to be unacceptable, then a costly retrofit program may be required to repair these piles since they cannot be visibly inspected. Addressing this problem will support or overturn a decision to eliminate cast-in-place piles from the mass concrete placement specification.

VI – Related Research

Little, if any, research is available. Some data exists on temperature variances based on instrumentation of piling for the new Benicia Bridge. Other existing contracts have similar temperature monitoring requirements. Therefore significant fieldwork may not be necessary, but only data analysis and reduction to applicable detrimental effects in CIDH piles may be required.

VII – Deployment Potential

The product produced will be a recommendation on the concerns related to the placement of mass concrete in large diameter cast-in-place. Also, these concerns should be weight against other potential problems in constructing cast-in-place piles and how they affect the performance of the pile.